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Implementation of TQM Tools for Enhancing Quality: A Case Study in the Ready-Made Garment Sector of Bangladesh

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Abstract

Total Quality Management (TQM) is a quality management tool for improving quality by addressing issues related to the entire production process. It involves the process of detecting wastes occurred on a regular basis to improve the product quality to increase customer satisfaction. This paper has explored the application of TQM tools to identify defects in the sewing line of garment industries and address such issues using Standard Operating Procedures (SOP).

In the garment industry, sewing defects still significantly impacts product quality and overall efficiency of the industry. Data on sewing defects occurred in production of a polo t-shirt are collected over a specified period using a check sheet, providing an insight into defect frequency. These data have been visualized through histograms to illustrate the distribution and highlight the common defects that has occurred in the production of the item. A Pareto analysis is then performed to identify the "vital few" defects that are contributing to the majority of quality issues. A Cause-Effect diagram is used to analyze the root causes and their interrelations for these identified critical defects. The outcome of this study has shown that implementation of SOP against these identified 20% of defects that are causing 80% of the problems in the sewing line, has significantly improved the quality standards and has also increased the 5S score from 102 to 163. With the application of these TQM tools, this research contributes to reduce sewing defects, improve product quality, increase 5S score and ultimately increase customer satisfaction.

Keywords:
TQM, 5S, SOP, Pareto analysis, Cause-effect analysis.

1. Introduction:
A polo t-shirt is a classic garment that is popular for its adaptability as it pairs well with jeans, shorts or even with blazer for smart semi casual looks. It is different than a regular t-shirt because of the soft ribbed collar and a buttoned placket, that usually comes with two or three buttons. These polo t-shirts are usually made from fabrics that are known for their comfort and breathable textures like blends of cottons and polyesters or jersey and pique fabrics. These are designed with both short and long sleeves but are more generally used as short sleeves and has slightly tailored structure which offers a more polished appearance compared to a standard t-shirt .The polo t-shirts are available in a wide range of colors and patterns that includes solid, striped, and even patterned designs, making it suitable for all kinds of occasions, ranging from casual to semi-formal. Even though polo t-shirts are considered as a mainstream fashion now, but its history dates back to early 20th century and its roots associates with sports. Today's modern polo t-shirt was first designed by Jean René Lactose, a world-class tennis player who was fondly called the alligator or crocodile because of his vicious playing tactics (Ahmed et al. 2018).

Before this, tennis players generally used to wear buttoned up long sleeves shirts made from heavy materials, which were impractical and uncomfortable on the court. Lacoste found these garments too restrictive for playing tennis and wanted to create something that is more functional and breathable. Due to this need, he designed a short-sleeved, lightweight cotton shirt with a soft collar and a buttoned placket. The fabric he had used for it is known as pique cotton. It was both breathable and durable making it an ideal active wear. After he wore his new shirt during U.S open in 1926, the revolution in tennis fashion had started. Even though it was primarily designed for tennis, the practicality and comfort quickly gained popularity in other sports, especially in polo. As a result, it became known as polo t-shirt. And this polo t-shirt entered the mainstream fashion due to Ralph Laurren in 1972 due to their newly launched clothing line of that time name polo. On that collection Laurren had featured versions of polo t-shirt with its iconic polo player logo and due to his marketing campaigns in magazines like VOGUE and GQ, it became a signature staple of status and class. Though you could certainly get less expensive pools, wearing the Lactose with its tiny alligator insignia on the chest was considered highly fashionable. It was associated with the 1980s "Preppy" look (Edalatpanah et al.2022)And by the year 1980 polo t-shirts took over the market in a way that it didn't remain as a sports item but also became a staple for business casual settings.

Due to the growing demand for this item, ensuring quality of its production in garments industry becomes crucial. But despite of the advancements in the manufacturing industries, sewing defects still remains a huge concern for its labor- intensive nature. Sewing defects like open seams, uneven stitches, puckering, raw edges, hem defects, button and collar attachment defects etc. hampers the product quality as well as customer satisfaction. These issues increase the production cost due to rework and wastages. Thus, it becomes a challenge for the garments industries to maintain the quality standards in today's competitive market. And to address these issues, application of Total Quality Management (TQM) plays a vital part. TQM refers to organization wide effort to achieve quality. It can accurately be described as a philosophy about quality that suggest for involving everyone in the organization in a quest for quality (Rahman 2013). Everyone in the organization, starting from top management body to workers are involved equally. It is the discipline dedicated to enhance quality in every aspect of an organization (Hasan et al. 2013). By implementing TQM effectively, a production environment can be ensured which delivers quality products (Syduzzaman et al. 2016). To implement it, seven basic tools are needed. In this paper the application of these TQM tools has been explored to detect and resolve sewing defects occurred in the production of polo t-shirts in garments

industries through methods like check sheets, histograms, Pareto analysis, and Cause-Effect diagrams. In addition to these tools, 5S and SOP frameworks has been applied to address these quality concerns

Total Quality Management (TQM):
The term Total Quality Management or more commonly known as TQM refers to the organization wise effort to achieve quality. It can be accurately described as a philosophy about quality that suggest for involving everyone in the organization in a quest for quality. It extends to suppliers as well as to customers. In fact, in TQM, the customer is the focal point, as the business is driven by customers. As such, customer's satisfaction is the main driving force(Rahman 2013). Thus, TQM always give emphasis on customer satisfaction to ensure quality culture by using continuous improvement concept (Rashid et al. 2016). To implement this TQM, seven basic tools are needed and it is stated that 95% of quality related problems can be solved with these quantitative tools.

SOP:
A SOP or Standard Operating Procedure is a type of written instructions that is designed to guide the employees of an organization through specific tasks or processes. SOP is substantially used in many industries that comprise manufacturing and service (Zur 2021). It provides a clear concept on how the steps should be performed for executing a task. These includes compliance with industry regulations, training new employees, and improving operational efficiency related concerns. Its overall outline's purpose of a procedure, its scopes as well as standardized methods of execution are given here across different shifts and departments.

5S:
5S is a key component in kaizen philosophy. The 5S tool helps everyone by making the opportunity to learn a culture of developing and maintaining a clean and organized working environment (Kumar et al. 2019). It is basically a workplace organization methodology that is designed to increase productivity and enhance efficiency and safety by creating a systematic and orderly arranged work environment. The philosophy of 5S interesting on eliminating waste and non-value activity which increases labor efficiency and work area safety (Seddik 2019)**.** This 5S methodology is derived from five Japanese words that represent the core principles of this approach. And these are-

- Sort (Seiri): It refers to identifying and separating necessary items from unnecessary items and then taking out those unnecessary items from the work area.
- Set in Order (Seiton): It involves arranging remaining required items for easy access.
- Shine (Seiso): In this step focus is given on regular maintenance and cleanliness to keep the workspace tidy.
- Standardize (Seiketsu): It refers to maintain a consistent procedure and practices in the organization.
- Sustain (Shitsuke): It means ensuring adherence to the standards through discipline and continuous improvement.

Pareto Analysis:
Pareto Analysis is a TQM tool that is used for decision making. It is used to identify the prominent factors that are contributing to a problem. It can be described as the 80/20 rule applied to quality-control (Bhosale et al. 2013). According to this analysis 80% of problems are mostly caused by 20% of the causes. Here data is collected and analyzed to identify these "vital few" causes that are responsible for the majority problems related to production system. And these data are represented with a chart called pareto chart to help in visualizing the factors that are causing maximum impact so that we know where action should be taken first.

Cause Effect Analysis:
Cause-Effect Analysis was invented by Dr. Kaoru Ishikawa in year 1968. This TQM tool is also known as a Fishbone Diagram or Ishikawa Diagram and is used to identify the root causes of a specific problem or issue. It is an analysis tool that provides a systematic way of looking at effects and the causes that create or contribute to those effects (Masoud Hekmatpanah 2011). It visually categorizes the potential causes which helps to explore how various factors such as materials, methods, machinery, and personnel contribute to the problem. Since with this diagram the possible causes are listed by categories, it becomes easier to target each reason thus helping us to solve the problem systematically.

1.1 Objectives:

- To identify and analyze critical defects occurring in the sewing line of polo t-shirts and find their root causes.
- To implement SOPs to address identified critical defects and evaluate their impact on reducing rework rates and improving production quality.
- To evaluate the impact of SOP implementation in the 5S score and production efficiency.

2. Literature Review:

Habib et al., 2021 says how TQM implementation in the RMG industries of Bangladesh has led to reduced waste, saved costs and ensured better utilization of resources by highlighting the positive impact of TQM tools, such as flow charts and cause-and-effect diagrams, on improving the overall production quality. He uses surveys and descriptive analysis to understand TQM practices among various garment factories in Dhaka but It lacks a detailed, step-by-step application of these tools for specific products or production phases. In contrast to it, in this paper TQM tools has been specifically applied by using a structured sequence of check sheets, Pareto analysis, and Standard Operating Procedures (SOPs) to achieve targeted quality improvements.

Khan et al., 2020 identifies the core pillars for TQM implementation in the ready-made garments sectors of Bangladesh. His study focuses on teamwork, customer satisfaction, continuous improvement, and quality control tools in significantly reducing waste and improving productivity. Even though he uses check sheets, flowcharts, and Pareto diagrams to analyze defect frequencies, a structured, sequential application of TQM tools in a specific production line has not been shown. But this paper uses TQM tools systematically on the polo t-shirt line, demonstrating step-by-step how check sheets, histograms, Pareto, and SOPs drive defect reduction and 5S improvements.

Zehir et al. 2012 uses surveys and statistical analysis to link TQM practices with performance outcomes. While the study demonstrates the positive impact of TQM on quality performance, it does not provide a specific methodology for applying TQM tools in a production line context. The broad approach leaves a gap in understanding the practical steps for quality improvement within a single product's manufacturing process. This paper applies TQM tools to the production of polo t-shirts, demonstrating each tool's operational impact through a sequence of check sheets, Pareto analysis. Furthermore, by incorporating SOPs and measuring 5S improvements, this study demonstrates the direct, operational impact of TQM on quality in a focused production context, offering a clear, actionable framework for practitioners.

Akter et al. 2015 applies general quality improvement methods, such as Kaizen and TQM, but lacks a detailed analysis of specific sewing defects. Tools like PDCA and 5S are used broadly without employing quantitative tools to prioritize critical defects systematically. Besides SOPs and 5S has been applied in general productivity terms but data on their effect on defect reduction has not been provided. While 5S and Kaizen are suggested, quantitative outcomes on their impact on RMG defect rates are insufficient. In this study critical defects have been prioritized, with cause-and-effect diagrams pinpointing root causes. By measuring defect rates and 5S scoring before and after SOP implementation, this research quantitatively validates their impact.

3. Methodology

- Collecting data on sewing defects that are occurring in the production line of a polo t-shirt.
- Illustrating these with application of histogram.
- Finding the "Vital few" defects that has most impact by conducting a pareto analysis.
- Making cause effect diagram for each of them for finding their root causes.
- Developing and implementing SOP to address the identified "vital few" defects.
- Measuring the effectiveness of SOP in reducing rework rates and improving quality standards by 5S score evaluation.

4. Data Collection:

Data collection using check sheets:

The check sheet also called a 'Defect Concentration Diagram' is basically a data collection sheet (Syduzzaman et al., 2014). Data collected using check sheets needs to be meaningfully classified. Such classification helps gaining a preliminary understanding of relevance and dispersion of the data so that further analysis can be planned to obtain a meaningful output (Magar & Shinde, 2014). The checksheet has been done to find the frequencies of defects occurred in the production of polo t-shirts in the sewing line of Multifabs Limited, floor A for over four days.

Table 1. Defects name in sewing section (Before)

Defects Name	Defects Quantity
Oil Spots	3016
Raw Edges	2453
Open Stitch	1247
Label Attachments	287
Dirty Spots	513
Shrinking	74
Pleats	1484
Pilling	169
Misaligned errors	141
Shading	334
Uneven Hem	306
Distorted Collar	113
Incorrect Sizing	53
Poorly Sewn Buttons	187
Misprinted Logos	67
Uneven Stitching	220
Irregular Patterns	139
Open Seams	154
Dropped Stitches	205
Diamond Open	101
Puckering	136
Loose Threads	322
Total Defects	11721

5. Results and Discussion:

5.1 Numerical Results:

Table 2. Data of sewing section before SOP Implementation

Date	Total Defect Quantity	Total Okay Quantity	Total Checked Quantity	Defects (Percentage)
21/08/24	4182	14011	15246	27.43%
22/08/24	2907	16657	18234	15.94%
24/08/24	2973	16105	176022	16.89%
25/08/24	1659	14477	15918	10.42%

Total	11721	61250	6700	17.49%

Table 3. Data of sewing section after SOP Implementation

Date	Total Defect Quantity	Total Okay Quantity	Total Checked Quantity	Defects (Percentage)
26/08/24	1768	15275	15939	11.092%
27/08/24	1058	15160	14783	7.157%
28/08/24	1641	15956	12983	12.640%
29/08/24	1156	17608	15258	7.576%
Total	5623	63999	58963	9.536%

The application of SOP in sewing line has significantly reduced the number of defects that occurs in the sewing line. The DHU has went down drastically with this implementation.

5.2 Graphical Results:

Data visualization using Histogram:

A histogram is a TQM tool that is often used for quality control. It looks similar to bar graphs or bar charts. Histograms organizes the data into continuous intervals showing how many data points fall within each range. The height of each bar represents the frequency of data points. Here we have used this quality control tool to visualize the shape and spread of a data sets of defects that we have found in sewing line of a polo t-shirt.

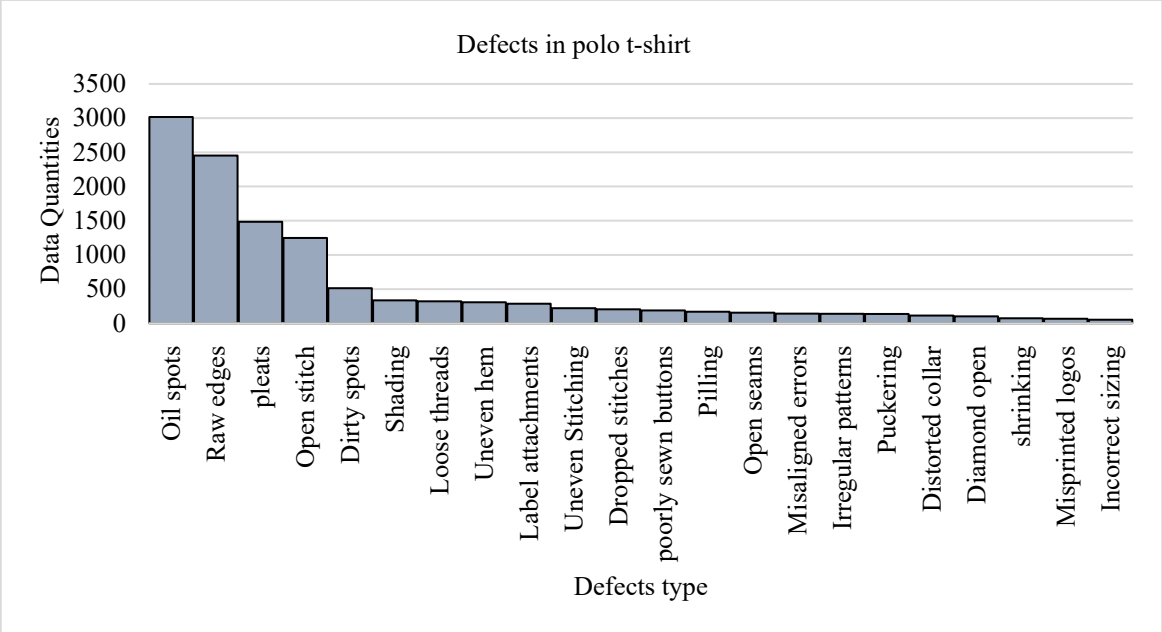


Figure 1. Histogram

Pareto Analysis:

Here pareto analysis has been done using the frequencies that were found for the sewing line of polo t-shirt from the check sheet previously to separate the “vital few” causes from “trivial many” causes so that the reason of 80% problems in the sewing line can be identified. And by taking actions against these 20% vital few causes, the wastages and reworks can be reduced.

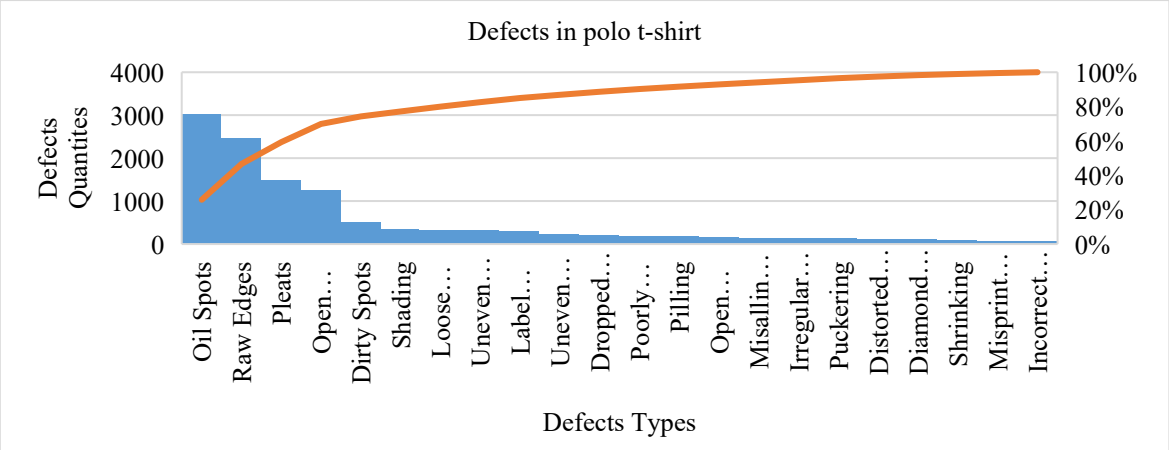


Figure 2. Pareto chart

5S Evaluation for Identified vital few defects Before SOP Implementation:

Table 4. 5S Scoring Before SOP Implementation

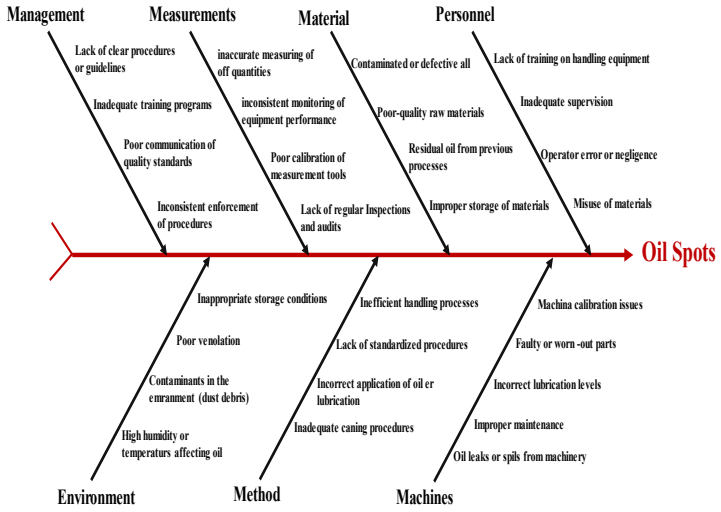
5S Element	Criteria	Oil Spots	Pleats	Raw edges	Open stitches	Comments
Sort	Removal of unnecessary items from the workplace area so that no unwanted items are on top of the equipment.	5	6	5	6	Work area isn't neatly kept because of piles of WIP products kept on the counter along with reworks and scrap fabrics.
Set in order	Proper organization of tools and materials for easy accessibility	6	6	6	8	Tools are to some extent organized but not properly as a result nonproductive time (NPT) increases and the process becomes inconsistent.
Shine	Adequate cleanliness of machine and workplace area	4	5	5	4	Work place area and machines are not cleaned properly on regular basis and thus there are remnants of oil/dirt spots, uncut threads extra causing fly contaminations.
Standardize	Adherence to organizations established procedures and guidelines	5	5	4	5	Existing guidelines and procedures for sewing line are not consistently followed thus occurrence of defects becomes frequent.
Sustain	Proper maintenance of cleanliness and procedural improvements	4	5	4	5	Measures that are taken against issues aren't sustained due to lack of proper inspection and maintenance thus efforts taken to maintain improvements fails.

5.3 Proposed Improvements:

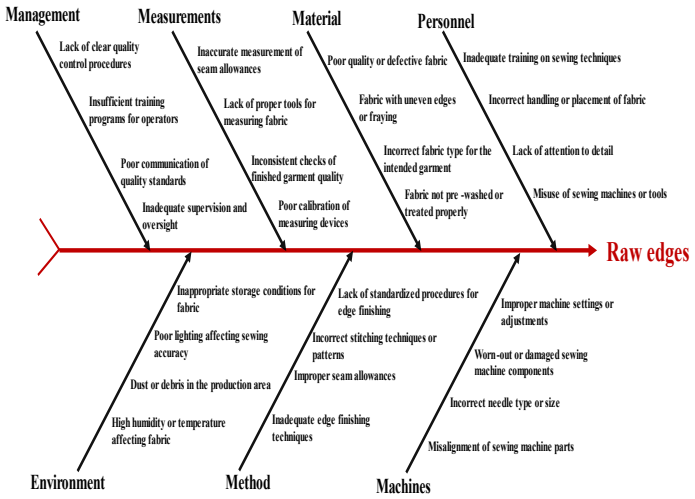
Cause effect diagram:

For the identified 20% vital few causes, a cause effect-diagram has been made-

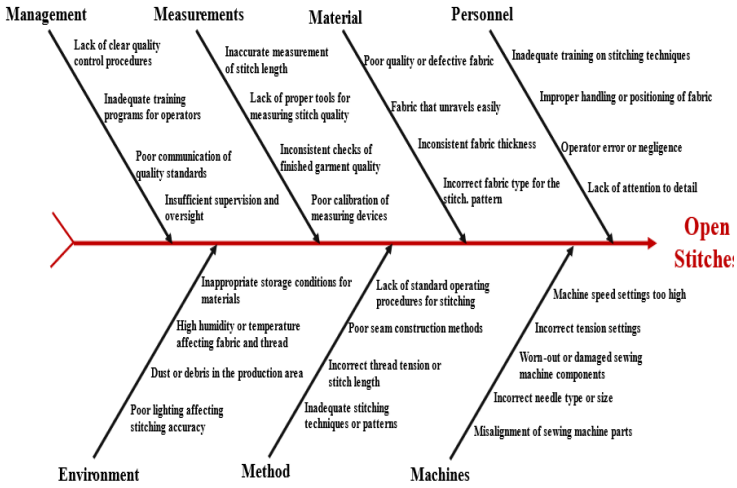
For Oil spots:



For Raw Edges:



For Open stitches:



For Pleats:

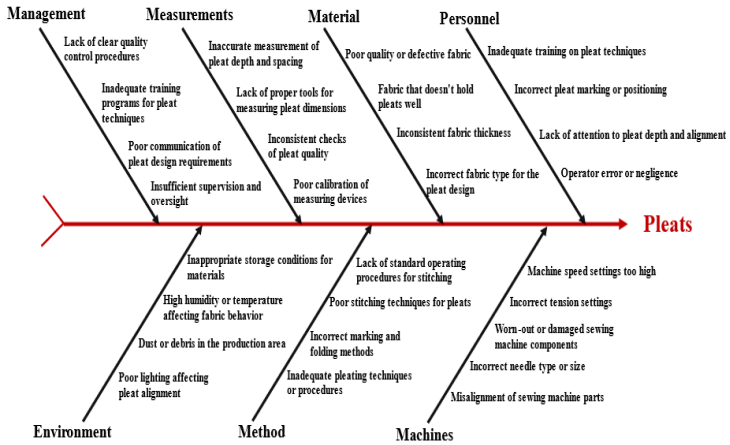


Figure 3. Cause-effect diagrams

Implementation of SOP for waste and defects reduction in sewing process

A Standard Operating Procedure or more commonly known as SOP is typically a guideline that provides step-bystep instructions to maintain consistency and quality in the production. This is vital for minimizing defects and waste occurred during the production. From the identified reasons behind major defects occurrence in the production of polo t-shirt from previous analysis are- oil spots, pleats, raw edges, and open stitch.

Developing the SOP for Identified Defects

Table 5. For Oil spots

Causes	Action Taken/Countermeasures
Cleaning Routine	Machines has to go through cleaning on regular basis both before and after shifts to prevent any kinds of oil buildup.
Operator Hygiene	It must be made sure that operators are maintaining proper hygiene, especially after lunch hour so that there is no chance of oil transfer. It should also be taken care of how any kinds of food items shouldn't be allowed in sewing floor.
Machine Maintenance	Maintenance technicians are required to check for oil leaks and lubricate machinery at defined intervals, use only the specified amount of oil.
Fabric Inspection	Fabric rolls should be inspected for oil stains before use, and stained fabric should be set aside for rework.

Table 6. For Raw Edges

Causes	Action Taken/Countermeasures
Seam Allowance Control	The seam allowance must strictly be maintained by the operators according to the buyer requirement. For example, if the buyer asked for 1.5cm allowance for seam allowance when stitching to avoid exposing raw edges, then all the operators and line in charges needs to ensure that it is being followed.
Edge Finishing	An overlock machine is used at the end of each seam to finish raw edges and prevent fraying.
Inspection Step	After sewing, in quality check area, every garment is inspected for exposed edges, and those with raw edges has to be set aside for rework.

Table 7. For Open stitches

Causes	Action Taken/Countermeasures
Needles	The operators must adjust the height of the needles and do testing before starting sewing in bulk. It should be checked that the needles are mounted properly in the sewing machine with right eye position (the hole through which the thread passes).
Thread Control	Operators has to check the thread tension before beginning each shift and starting bulk production to ensure tight and secure stitches to avoid reworks.
Stitch Inspection	Operators or line QC has to perform a random pull test on every 10th garment to check for any kinds of loose stitches.
Repair SOP	If open stitches are detected, the garment must be immediately sent back to the operator for repair, following the "repair SOP" that includes securing the stitch with a backstitch.

Table 8. For Pleats

Causes	Action Taken/Countermeasures
Fabric Handling:	It should be ensured that the fabric is being fed into the machine at a consistent speed to avoid bunching (unintentional gathering or folds that creates wrinkles). Operators are instructed to stretch the fabric slightly before starting the processes to prevent pleating.
Machine Tension	he tensions on the sewing machine has to be set correctly to avoid the gathering in the fabric
Pinning Guide	For critical seams, guide pins must be used to keep the fabric in place and aligned before sewing.

Evaluation for Identified vital few defects after SOP Implementation:

Table 9. 5S Scoring After SOP Implementation

5S Element	Criteria	Oil spots	Pleats	Raw edges	Open stitches	Comments
Sort	Removal of unnecessary items from the workplace area so that no unwanted items are on top of the equipment's.	9	8	9	8	Workplace areas are now neatly organized with all unnecessary items removed that were previously hindering smooth operation of the process as well as safety is ensured.
Set in order	Proper organization of tools and materials for easy accessibility.	8	8	8	9	Tools and materials are now organized in systematic manner thus it's easier to access needed items causing nonproductive time to reduce significantly.
Shine	Adequate cleanliness of machine and workplace area.	9	8	9	8	Workplace area and machines are now regularly cleaned and maintained thus there is no more remnants of oil spots or unnecessary threads.
Standardize	Adherence to new SOPs and standardized procedures and guidelines.	8	8	8	9	SOPs are followed consistently now which prevents the occurrence of frequent defects.
Sustain	Proper maintenance of cleanliness and adherence to SOP's.	7	7	7	8	Actions taken again the problems and improvements are maintained now, occasional reminders and checks are done to ensure continued adherence.

Analysis from the before and after evaluation of implementing SOP
We can see that the 5S scores for oil spots has improved after SOP implementation in the sewing line of polo t-shirt from 4 to 9, showing a visible reduction in occurrence of oil spots now as regular and consistent cleaning routines are maintained now.

The 5S score went from 5 to 8 for pleats, showcasing a better fabric handling and machine adjustments to prevent unintentional pleats during the production of a polo t-shirt.

The score increased from 5 to 9 for raw edges after the SOP implementation, showing that proper seam allowances and overlock machine usage have effectively minimized raw edges.

The score improved from 4 to 9, indicating how consistent needle maintenance and thread tension checks have reduced open stitches.

5.4 Validation

Table 10. Total 5S score Before and After SOP implementation

Defects	Sort		Set in order		Shine		Standardized		Sustain		Total sum (out of 50)	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Oil Spot	5	9	6	8	4	9	5	8	4	7	24	41
Pleats	6	8	6	8	5	8	5	8	5	7	27	39
Raw Edges	5	9	6	8	5	9	4	8	4	7	24	41
Open Stitches	6	8	7	9	4	8	5	9	5	8	27	42
Total											102	163

6. Conclusion:

This study highlights the effectiveness of applying Total Quality Management (TQM) tools, like check sheets, histograms, Pareto analysis, and Cause-Effect diagrams chronologically to find the root causes and then taking action against them to improve the quality of polo t-shirt production by reducing defects and increasing efficiency through the implementation of SOPs. The actions taken against the identified major causes has shown significant improvement as the rework and wastes has reduced quite drastically. Besides this SOP application has reduced all non-productive activities in the sewing line which can be seen clearly from the before and after 5S score evaluation as the 5S has score has went from 102 to 163 after this. Though this research was limited to a single product which is a polo t-shirt and its production setting, and focused mainly on the sewing line, future studies could be expanded in to other garment types by including multiple production cycles, and integrate digital systems for real-time monitoring. Besides exploring the impact of employee training on sustaining quality improvements could also provide valuable insights for long term success in garment manufacturing.

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